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PDES APPLICATION PROTOCOL SUITE FOR COMPOSITES (PAS-C)

1992 Annual Report for the PAS-C Program

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This technical report has been reviewed and is approved for publication.

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Project Manager

DATE

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This annual report conveys the accomplishments of the PDES Application Protocol Suite for Composites (PAS-C) Program for the period September 1, 1991 through August 31, 1992. This time period primarily covers Phase I, the Needs Analysis, and the kickoff of Phase II, Application Protocol Development. The report also describes how these accomplishments will be used in the upcoming program phases.

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LIST OF ABBREVIATIONS AND ACRONYMS

AAM	Application Activity Model
AIM	Application Interpreted Model
AP	Application Protocol
ARM	Application Reference Model
ATMCS	Advanced Tooling Manufacture for Composite Structures
CAD	Computer Aided Design
CSL	Contoured Skin Laminate
CSP	Core Stiffened Panel
DPD	Digital Product Definition
FEA	Finite Element Analysis
FW/BB	Framework/Building-Block
HoQ	House of Quality
IGES	Initial Graphics Exchange Specification
IPO	IGES/PDES Organization
IPT	Integrated Product Team
IRB	Industry Review Board
ISO	International Organization for Standardization
ManTech	Manufacturing Technology
MATCOPS	Manufacture of Thermoplastic Composite Preferred Spares
NC	Numerical Control
NIST	National Institute of Standards and Technology
PAS-C	PDES Application Protocol Suite for Composites
PDES	Product Data Exchange using STEP
SDAI	STEP Data Access Interface
SOTA	State-of-the-Art
STEP	Standard for the Exchange of Product Model Data
TCA	"T" Composite Assembly
VIG	Vendor Implementation Group

1 INTRODUCTION

This annual report conveys the accomplishments of the PDES Application Protocol Suite for Composites (PAS-C) Program for the period September 1, 1991, through August 31, 1992. This time period primarily covers Phase I, the Needs Analysis, and the kickoff of Phase II, Application Protocol (AP) Development. The report also describes how these accomplishments will be used in the upcoming program phases.

The overall objective of PAS-C is to reduce the cost of aircraft composite structural components through the use of concurrent engineering practices enabled by standardized product information used in their exchange environments. The PAS-C Program's focus is on standardizing the product information that is exchanged within these environments and then developing and demonstrating three of these exchange environments. The demonstration will validate the completeness and usefulness of this standardized product information for these three exchange environments. The results of PAS-C will allow for the exchange and storage of composite part information among life-cycle stages. The life-cycle stages in scope are Analysis, Design, Manufacturing, and Support as shown in Figure 1. The PAS-C Program intends to establish these data exchange standards utilizing the International Organization for Standardization (ISO) product information standard STEP (STandard for the Exchange of Product model data). The standardized product information that is exchanged within these environments are equivalent to Application Protocols (APs) within STEP.

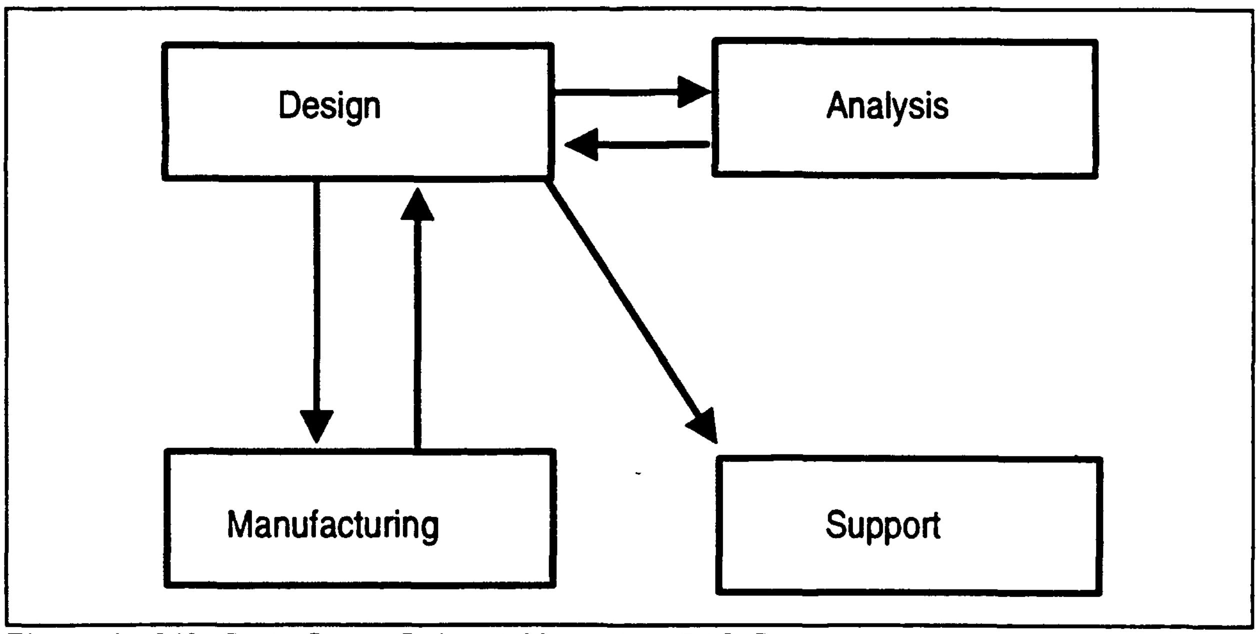

Figure 1 - Life-Cycle Stages Being Addressed by PAS-C

Phase I, the Needs Analysis, consisted of a set of tasks aimed at:

- Establishing clear and comprehensive composite part informational requirements,
- Insuring these part informational needs can be satisfied using STEP,
- Identifying and prioritizing potential benefits from utilizing this part information in a standard information exchange environment, and
- Generating a plan for the development and demonstration of the integrated Application Protocols (APs).

PAS-C is two months into Application Protocol Development (Phase II). The Tasks that will be accomplished are:

- Obtaining industry consensus on the scope of each Application Protocol,
- Creating comprehensive models, depicting the interrelationships of the information being exchanged within the Application Protocols, and
- Generating test criteria that will aid in validating implementation of the Application Protocols.

2 ACCOMPLISHMENTS

This section will identify specific accomplishments of the PAS-C program and how they are being utilized within PAS-C and industry. To keep this document as concise as possible, references to PAS-C program deliverables will be utilized whenever feasible providing supporting detail data as required.

The accomplishments in the following sections are the results of the tasks presented on the Phase I schedule in Figure 2. All these tasks were completed on schedule and within budget. Detail schedule performance can be found in the program deliverable *PAS-C Program Project Planning Chart* [1].

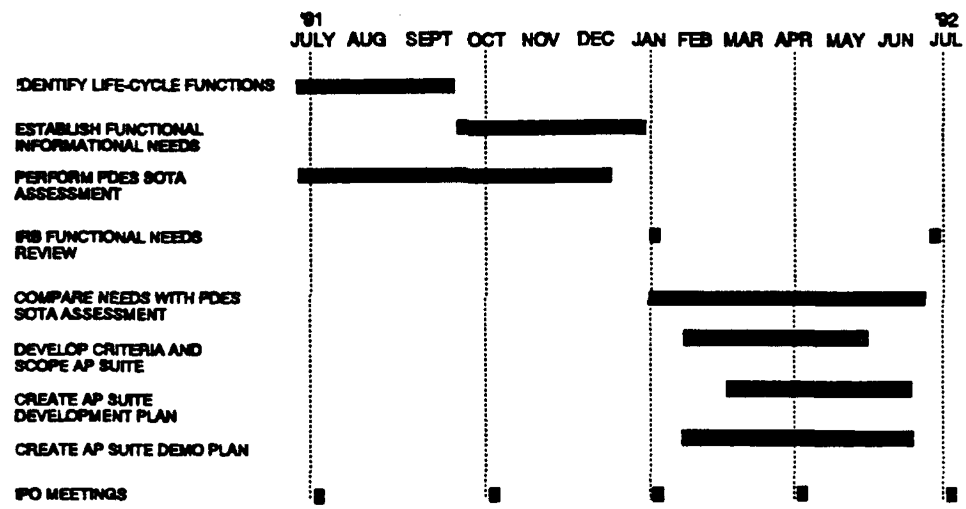

Figure 2 - Phase I Needs Analysis Schedule

2.1 Identified Needs

A large portion of the PAS-C team's effort during Phase I was spent on identifying composite part information needs. The needs gathering process consisted of:

- Selecting a set of part families to establish scope,
- Standardizing composite constituents terminology,
- Capturing informational characteristics per functional view,
- Identifying a comprehensive set of life-cycle activities unique to composites, and

- Constructing an extensive IDEF0 model tying the informational needs to their functional requirements.

The purpose of selecting a set of part families was to insure that the prominent structural composite parts used in the Air Force would be supported. The results of the part family selection is shown in Figures 3, 4, and 5.

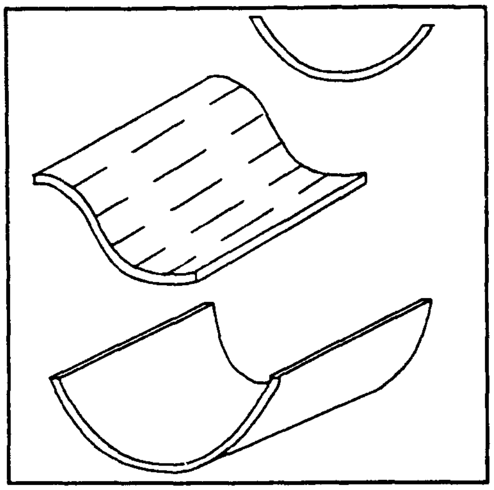

Figure 3 - Contoured Skin Laminate (CSL) - Ply Laminate General

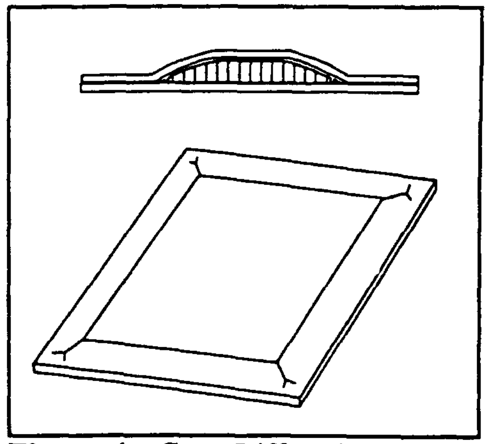

Figure 4 - Core Stiffened Panel (CSP) -Composite Layup/Assembly - Stiffened Panel (Core)

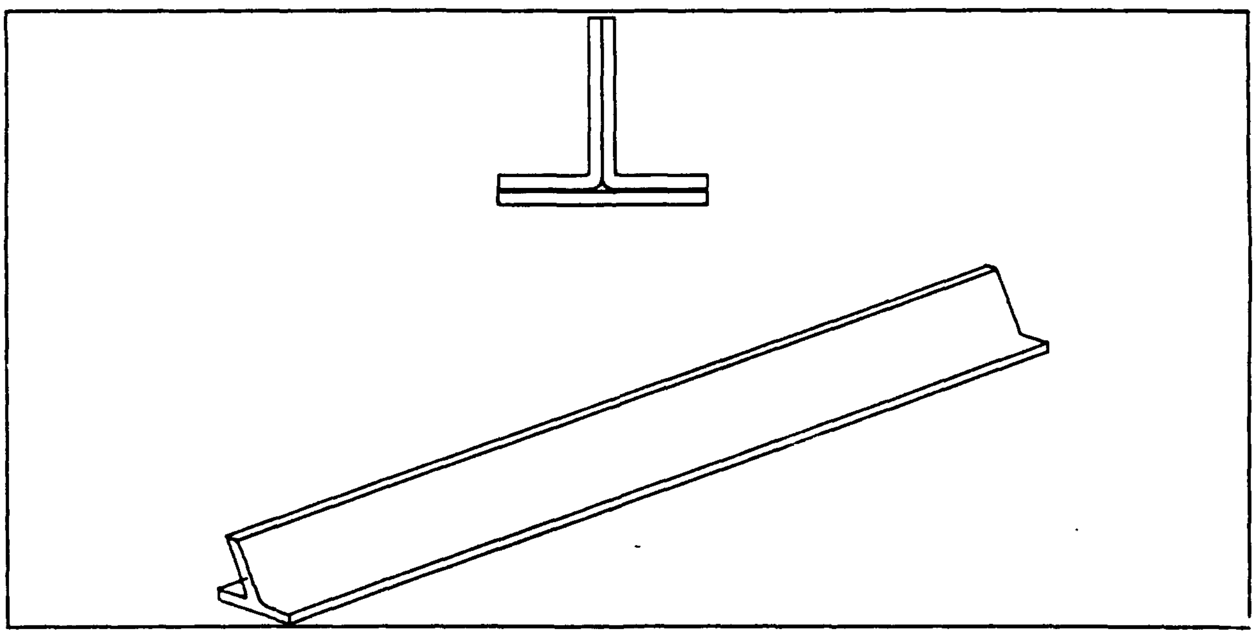

Figure 5 - "T" - Composite Assembly (TCA) Composite Layup/Assembly - "T" Section

The three part families, Contoured Skin Laminate, Core Stiffened Panel, and "T" Composite Assembly are the prominent part types. They are made up of the majority of basic constituents that all other structural parts consist of; thus, indirectly covering a larger spectrum of composite parts than just the three shown. The program deliverable *Functional Needs Report for the PAS-C Program* [2] contains the analysis for part family selection and example part selection. The program deliverable *PAS-C Sample Part Set* [3] identifies the three example parts to be used in the Demonstration Phase (Phase III) and contains the actual released part drawings.

As an aid in standardizing and organizing composite part information, some standard terminology had to be established. This terminology consisted of standard descriptions for the components that make up any composite part and functional view descriptions. Figure 6 shows these standard composite components as composite items and gives examples. This list of composite items in Figure 6 represents physical constituents that can stand on their own during at least one stage in the creation of a composite part.

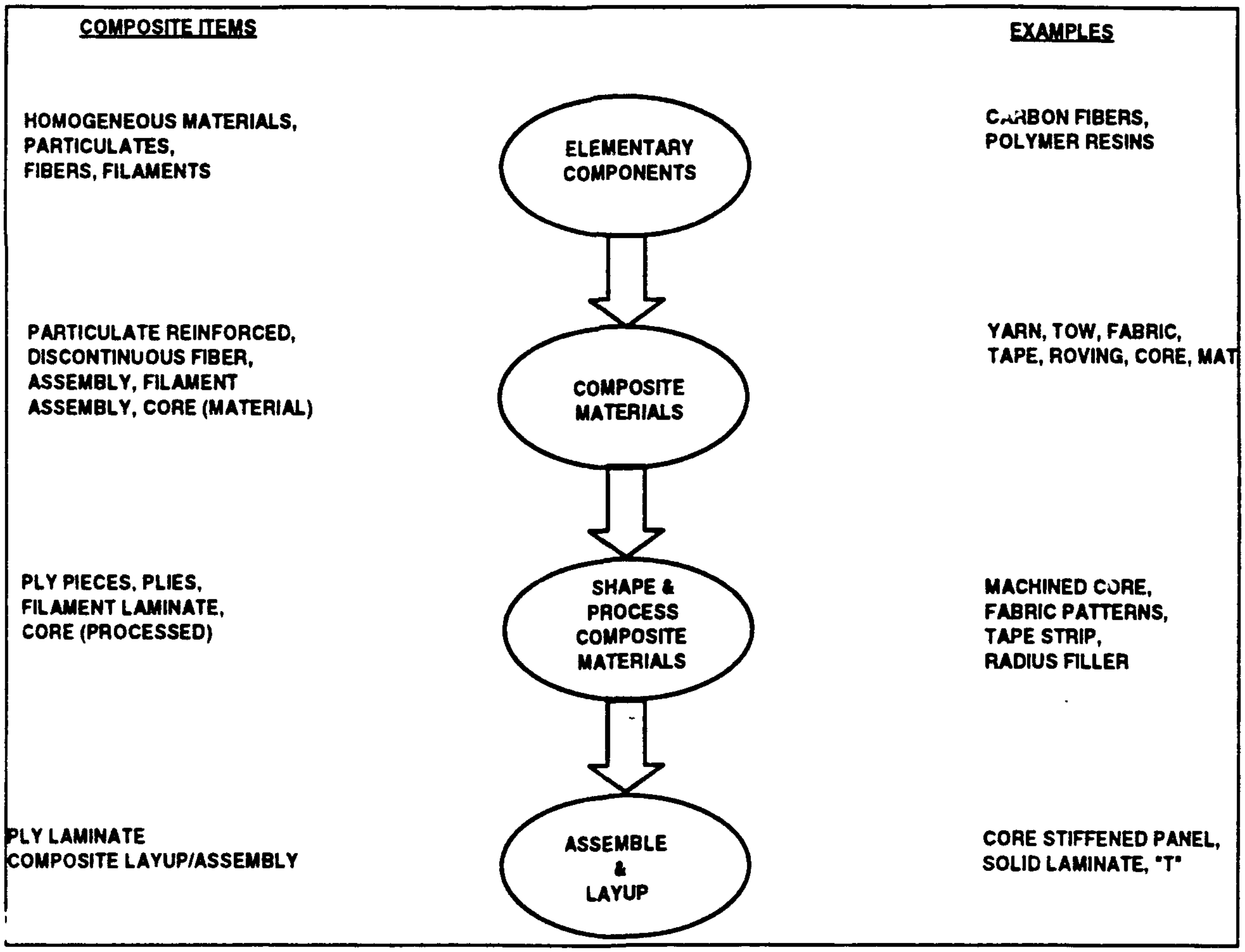

Figure 6 - Composite Item Relationships

Figure 7 shows how these composite items and the functional views were used to decompose and organize composite part information over its life-cycle stages. This structure is what PAS-C refers to as the Framework/Building-Block (FW/BB) method. FW/BB is a comprehensive methodology for capturing characteristics about a specific composite item from multiple functional views. Capturing the information in this generic manner allows for this knowledge to be reused by other projects. The results of utilizing this methodology for composites and the documentation of terminology used can be found in *Functional Needs IDEF0 Activity and Information Models for the PAS-C Program* [4].

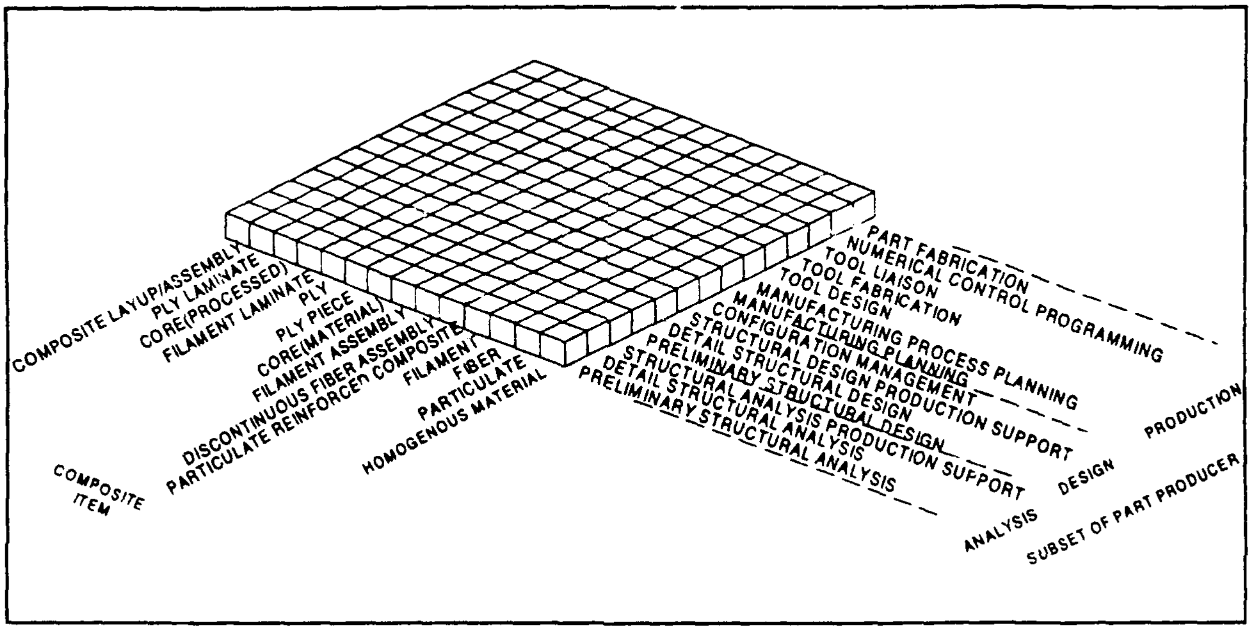

Figure 7 - Composite Product Item Suite Information Organizational Structure

An extensive activity model was developed for composites covering the areas of product analysis, design, and manufacturing. Additional detail descriptions for each of the three part families were created by decomposing the activity model further in the areas where specialized activities existed. This information model was created and reviewed by composite experts in three of the most prominent composite aircraft component manufacturers in the world: Vought Aircraft, General Dynamics, and Boeing. This model is the basis for tying the product information back to its real functional needs. This model will be used as the cornerstone for creating the specific Application Activity Model (AAM) for each of the APs within PAS-C. Figure 8 shows one of the diagrams out of the IDEF0 model. Activity node tree diagrams and their definitions are also included with the IDEF0 model in reference [4].

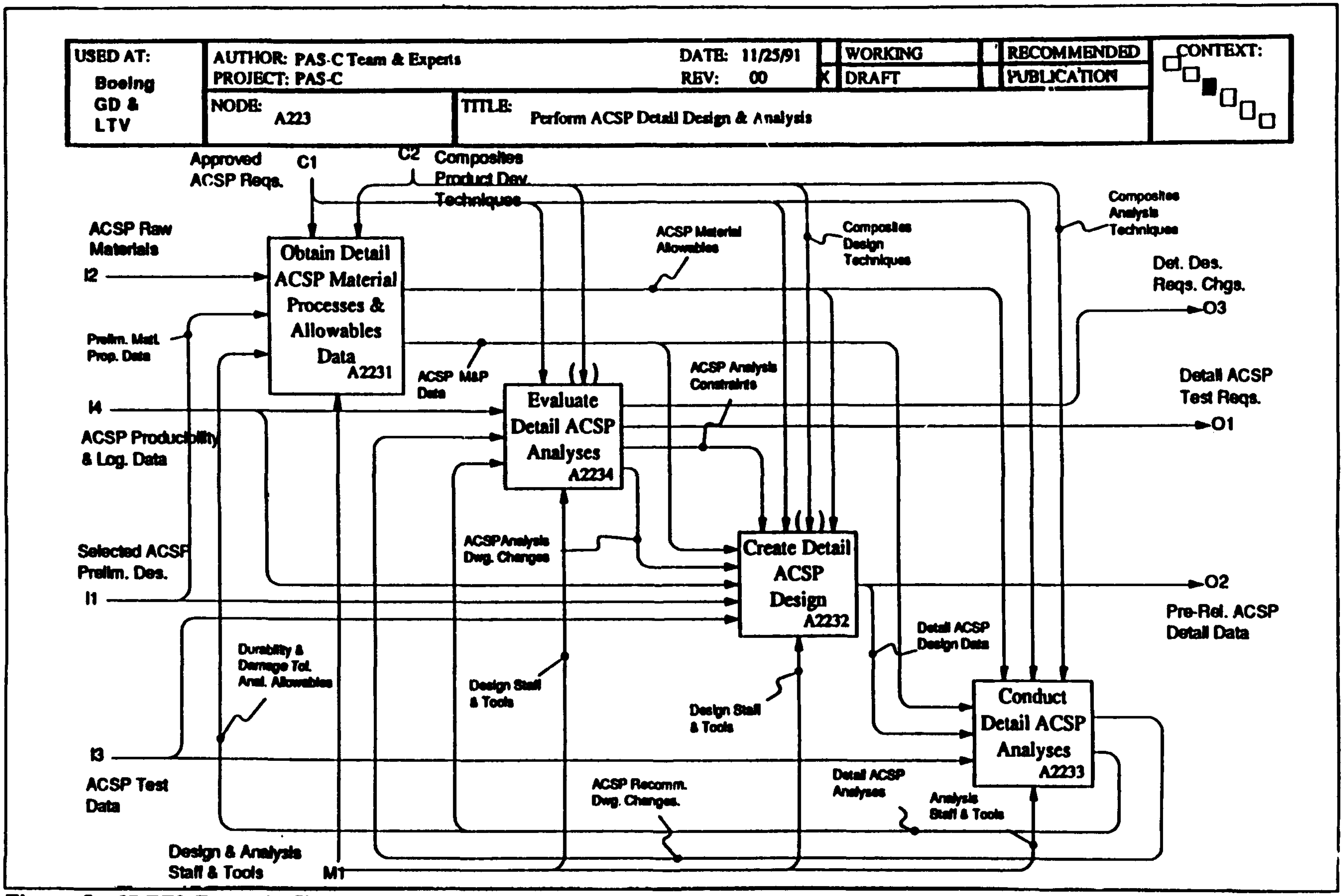

Figure 8 - IDEF0 Example Sheet

2.2 PDES State-of-the-Art Assessment

A State-of-the-Art (SOTA) Assessment of PDES (Product Data Exchange using STEP) was accomplished in Phase I. The assessment was restricted to those areas that may impact the achievement of the PAS-C goal of developing an Application Protocol Suite (AS) for composite parts. The assessment covered the STEP baseline documents shown in Table 1. This Table depicts the likelihood of which documents apply directly to PAS-C and the date of the document that was evaluated.

Table 1 - PDES State-Of-The-Art Assessment Sources

Part No.	STEP Part Title / Related Document Title	Applies to PAS-C	Base-lined
1 •	Overview and Fundamental Principles	Yes	Oct 91
11 •	EXPRESS Language	Yes	Apr 91
21 •	Clear Text Encoding of the Exchange Structure	Yes	Mar 91
31 •	Conformance Testing Methodology and Framework: General Concepts	Yes	Jan 91
41 •	Fundamentals of Product Description and Support	Yes	Oct 91
42 •	Geometric and Topological Representation	Yes	Jun 91
43 •	Representation Structures	Yes	Jul 91
44 •	Product Structure Configuration	Yes	Aug 91
45	Materials	Yes	Dec 90
46 •	Visual Presentation	Yes	Oct 91
47	Shape Tolerances	Yes	Dec 90
48	Form Features Information Model	Maybe	Aug 90
101 •	Draughting Resources	Yes	Aug 91
104	Finite Element Analysis	Yes	Oct 91
201 •	Explicit Draughting	Maybe	Oct 91
202	Associative Draughting	Maybe	Oct 91
203 •	Configuration Controlled Design	Maybe	Sep 91
204	Mechanical Design using Brep	Maybe	Oct 91
205	Mechanical Design using Surface Representation	Maybe	Oct 91
206	Data Transfer of Wireframe Models via the Physical File	Maybe	Jul 90
XXX	Process Plan Model	Yes	Apr 91

* INDICATES INITIAL RELEASE PART

Each document represents a Part in STEP. A Part is one portion of the Standard and is assigned to a particular class within the Standard. These classes are:

- Overview,
- Description Methods,
- Implementation Forms,
- Conformance Testing,
- Integrated Resources, and
- Application Protocols.

Each Part was evaluated based upon maturity, content, stability, and adherence to ISO methods. A brief summary of each Part was also provided as an introduction to that Part's assessment. An overview of the relevant standards organizations and the processes that must be completed to make an Application Protocol for PAS-C was also created as part of the assessment. The PAS-C document that contains this assessment is the *PDES State-of-the-Art Assessment for the PAS-C Program* [5]. The research that went into formulating this document has provided valuable knowledge in determining a doable scope for PAS-C.

2.3 Functional Needs to PDES SOTA Comparison

A comparison of the identified functional needs to PDES/STEP capabilities and contents was performed in Phase I. The Quality Function Deployment House of Quality (HoQ) methodology was used to correlate the information needs to available PDES/STEP resources. Voids in the STEP Part resources where needs were not met were identified. A cost to fill each void was estimated. Then the needs were prioritized with respect to both benefits to the PAS-C Program objectives and to cost.

The results concluded that all but a few of the voids found during the comparison were not judged to be serious. It was recommended that the majority of the identified voids be addressed by the PAS-C Application Protocol Suite, with the remainder to be addressed by liaison with the PDES/STEP effort to enhance the PDES/STEP information model resources.

Based upon the comparison of PAS-C composite informational needs to PDES/STEP resources, it appears that the IPO/ISO has addressed the more critical areas of information. The analysis indicated that there are no critical voids within PDES/STEP that would adversely alter PAS-C goals. It was concluded that the risk of relying on PDES/STEP development processes and resources would be manageable.

2.4 Scope and Benefits

Phase I, the Needs Analysis, consisted of a set of tasks aimed at establishing clear composite part informational requirements. These informational requirements were prioritized based on potential benefits from utilizing PAS-C's demonstration part information in a standard information exchange environment. These potential benefits were derived by composite experts from their respective functional disciplines of Analysis, Design, Manufacturing and Support. Using the IDEF0 model from the Identified Needs task (as described in section 2.1) potential benefits were estimated by the experts.

Figure 9 graphically represents the groupings of the various information exchange environments evaluated. Each of the circled areas shows one of the major exchanges and clearly depicts the overlap between the exchanges. Appearing on the diagram are the following high level information exchanges and a reference back to the IDEF0 diagrams ID's that appeared in reference [4]:

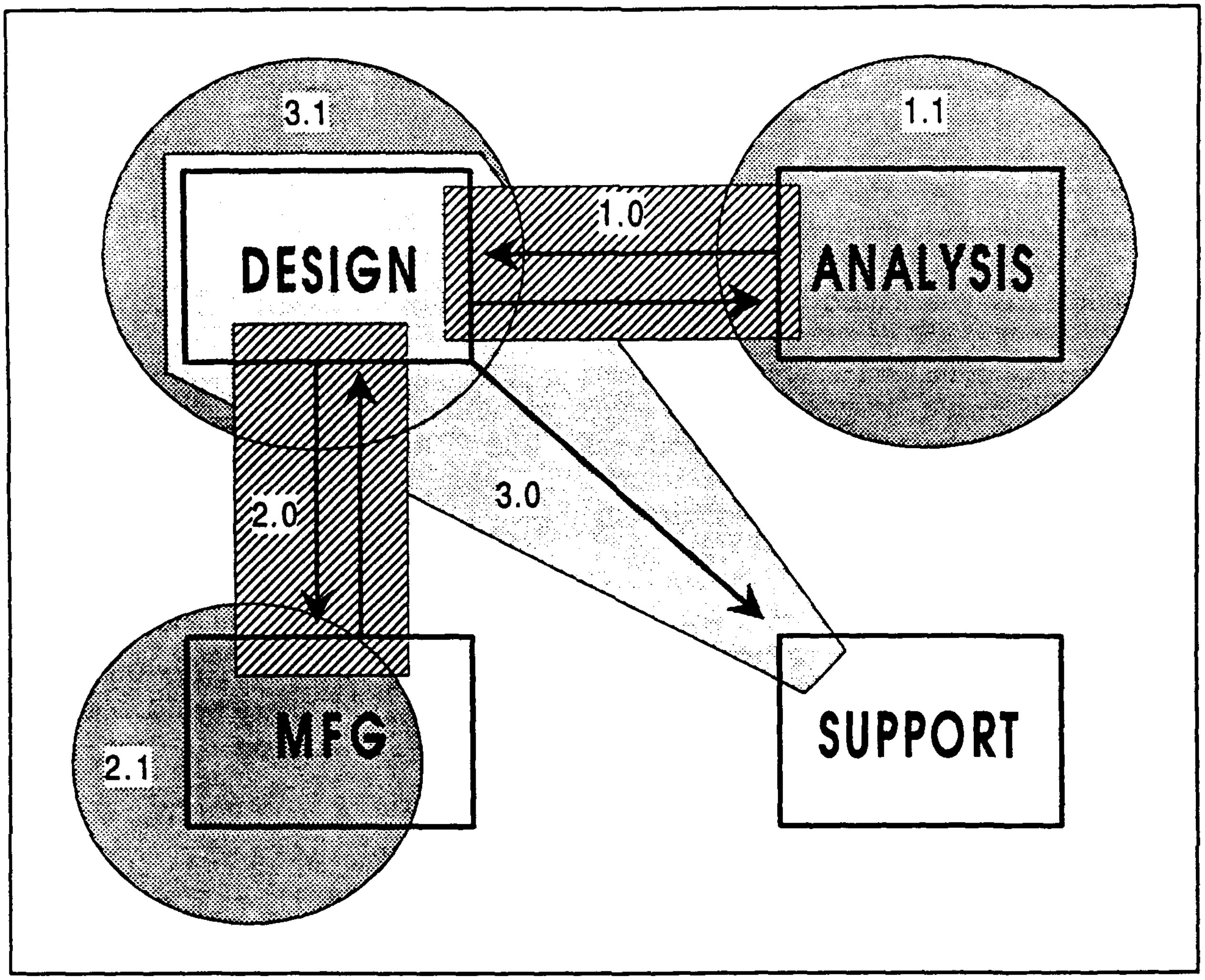

Figure 9 - AP Data Exchange Scopes

- 1.0 - Design to Analysis (diagram ID - A223)
- 1.1 - Internal for Analysis (diagram ID - A2233)
- 2.0 - Design to Manufacturing (diagram ID - A2)
- 2.1 - Internal for Manufacturing (diagram ID - A23)
- 3.0 - Design to Support (diagram ID - A0)
- 3.1 - Internal for Design (diagram ID - A2232)

Based on these benefits, the three Application Protocols within the Suite (Design to Analysis, Design to Manufacturing, and Design to Support) were scoped. These APs only address a portion of the total life cycle of a composite part's information exchange. However, PAS-C has established that this is the most significant portion that can be standardized today. Focusing on exchanges from the design function will allow PAS-C to capture the core exchange information. One of the Designer's primary tasks is to put the information of a composite part into a general format that any other functional area can extract. Today this is done through a drawing. The three APs PAS-C will create will not only allow the information about the part to be extracted visually but will also allow for intelligent applications to directly access the captured part knowledge.

Figure 10 shows different aspects of each of the three AP areas. The different aspects were

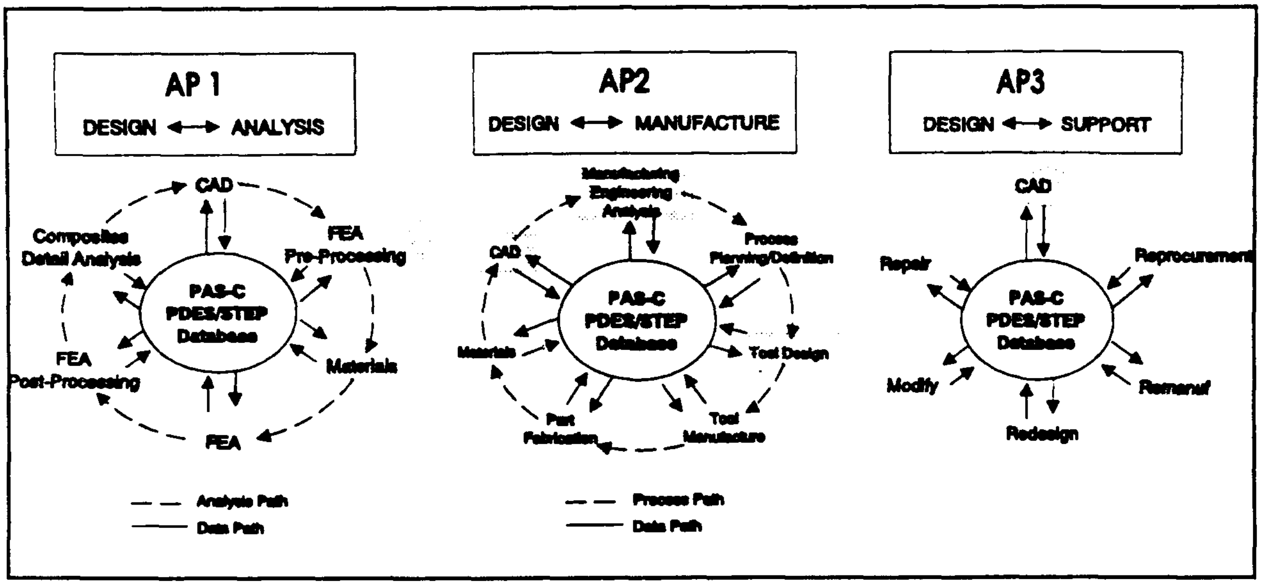

Figure 10 - Application Protocols

prioritized as to which ones would be addressed first (as shown by the highlighted areas). In AP1, Design to Analysis, the primary focus will be on the exchange of information between Computer Aided Design (CAD), Finite Element Analysis (FEA) Pre-Processing, Materials, and Composite Detail Analysis. The other two areas of FEA and FEA Post-Processing will be addressed but will only be validated as time permits. This AP will satisfy many stated requirements within industry, as well as many emerging needs within the Air Forces's Air Logistics Centers for standardized FEA data. In AP2, Design to Manufacturing, the primary focus will be on the exchange of information between CAD, Manufacturing (MFG) Analysis, and Tool Design. The aspect of capturing the detail process information was out of scope as is the output of all of the typical detail MFG Engineering functions such as output like NC programs and tool designs. This AP will serve many industries that sub-contract their manufacturing work out because it will allow a more complete and computer interpretable definition of the component (e.g., 3-Dimensional Ply Data). In AP3, Design to Support, the primary focus will be on providing an Engineering release package suitable for remanufacturing the part. Information that satisfies Reprocurement needs will more than likely be included to meet the Remanufacturing scenario. This AP is focused at satisfying the near term needs of the Air Force for acquisition of the traditional drawing with some of the high payback data such as Bill of Materials and 3-Dimensional Contour. This AP is also seen as a bridge to get from current 2-Dimensional drawing practices to a full 3-Dimensional product model.

Table 2 shows the results of the preliminary activity cost analysis when applied to the three PAS-C demonstration parts. These results were formulated by running each demonstration part through the activity cost analysis evaluating each of the application protocols (Design to Analysis, Design to Manufacturing, and Design to Support). The values in Table 2 reflect the summation of the activity cost analysis results for each of the three application protocols when only their highest payback data exchange scenario was considered. The three demonstration parts are a Contoured Skin Laminate (CSL), Core Stiffened Panel (CSP), and "T"-Composite Assembly (TCA). The value represents labor hours to perform the life-cycle tasks. Table 2 shows the hours it takes today (AS-IS) to perform the tasks and the hours it is estimated to take when the application protocols are implemented (TO-BE).

Table 2 - PAS-C AP Suite Implementation Preliminary Activity Cost

DEMO PART	PAS-C AP SUITE IMPLEMENTATION			
	AS-IS	TO-BE	Δ HOURS	REDUCTION
CSL	2184	1811	373	17%
CSP	4401	3623	778	18%
TCA	660	556	104	16%

These three Application Protocols showed the highest payback with the criteria that the PAS-C Program has developed. The activity cost analysis that was run against the demonstration parts did not account for many of the cost items that are very hard to quantify such as: better configuration control, fewer paper requirements, reduction/elimination of lost data, and schedule reduction. Even though these very hard to quantify cost items were not accounted for, the calculated benefit for implementing the PAS-C AP Suite could have been over 1200 hours for the respective PAS-C demonstration parts.

Detail descriptions of the AP scopes and supporting benefits activity cost analysis data can be found in documents *Scoping and Benefits Criteria (Volume I - Executive Summary and Overview) for the PAS-C Program* [6] and *Scoping and Benefits Criteria (Volume II) for the PAS-C Program* [7].

2.5 Development Plans

A major accomplishment of the PAS-C Program was to formulate and initiate a comprehensive and detailed plan for developing an integrated set of STEP APs. The plan not only includes the basic AP creation tasks such as AAM, ARM, AIM, and test purposes, but also the consensus building tasks such as international expert reviews and STEP qualification/ integration workshops. This development plan integrates both the Air Force and ISO requirements and deliverables into a challenging schedule. The plan outlines the tasks to create two STEP compliant APs and one AP that satisfies Air Force needs but has not completed all STEP requirements.

The basic components of an AP are shown in Figure 11 . The order in which these components are developed is important because each builds off the previous one. The development order of the components are:

- Scope/Requirements & Commonalities (AAM)
- Application Reference Model (ARM)
- Application Interpreted Model (AIM)
- Conformance Requirements & Test Purposes
- Abstract Test Suite

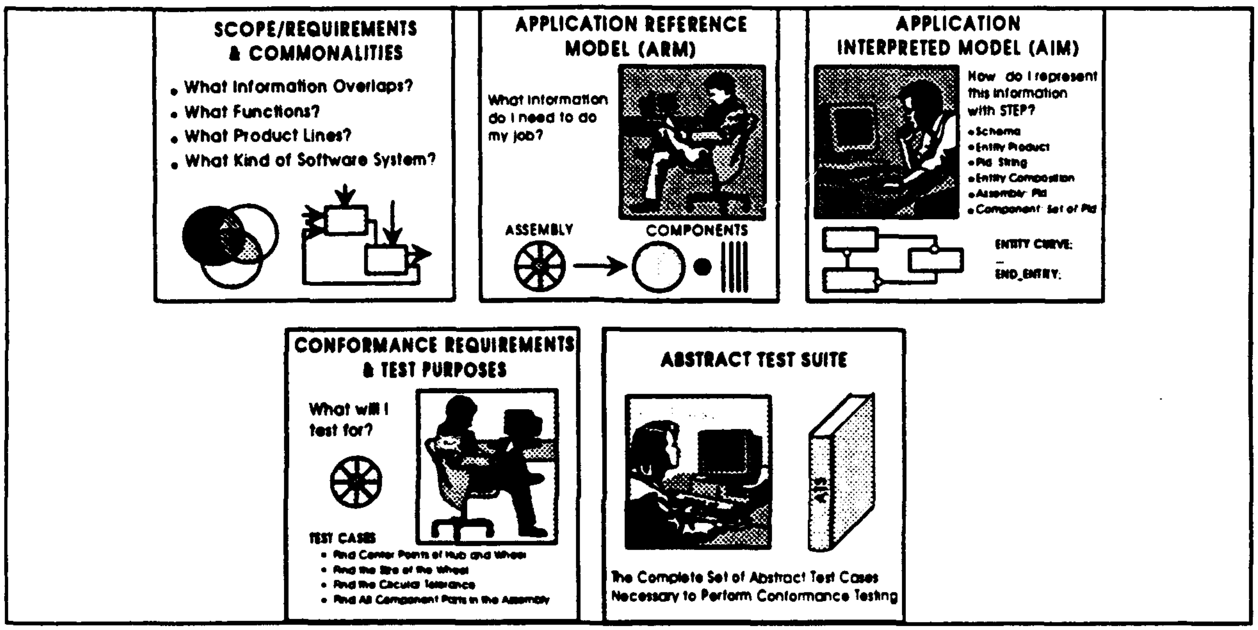

Figure 11 - Components of an AP

In building an integrated suite of APs, the first component is very critical. To insure that the APs are integrated, extra effort in identifying commonalities in scope is essential. The PAS-C team accomplished this by identifying common characteristics of standard composite part components from the perspective of different functional/discipline views. These common characteristics form the basis for a common information model that will be developed in Phase II.

Figure 12 shows a high level view of Phase II tasks. A detail schedule for Phase II is located in Appendix B of the *Program Master Plan for the PAS-C Program* [8]. Descriptions of these detail tasks can be found in Section 3 of the *Development and Demonstration Plan for the PAS-C Program* [9].

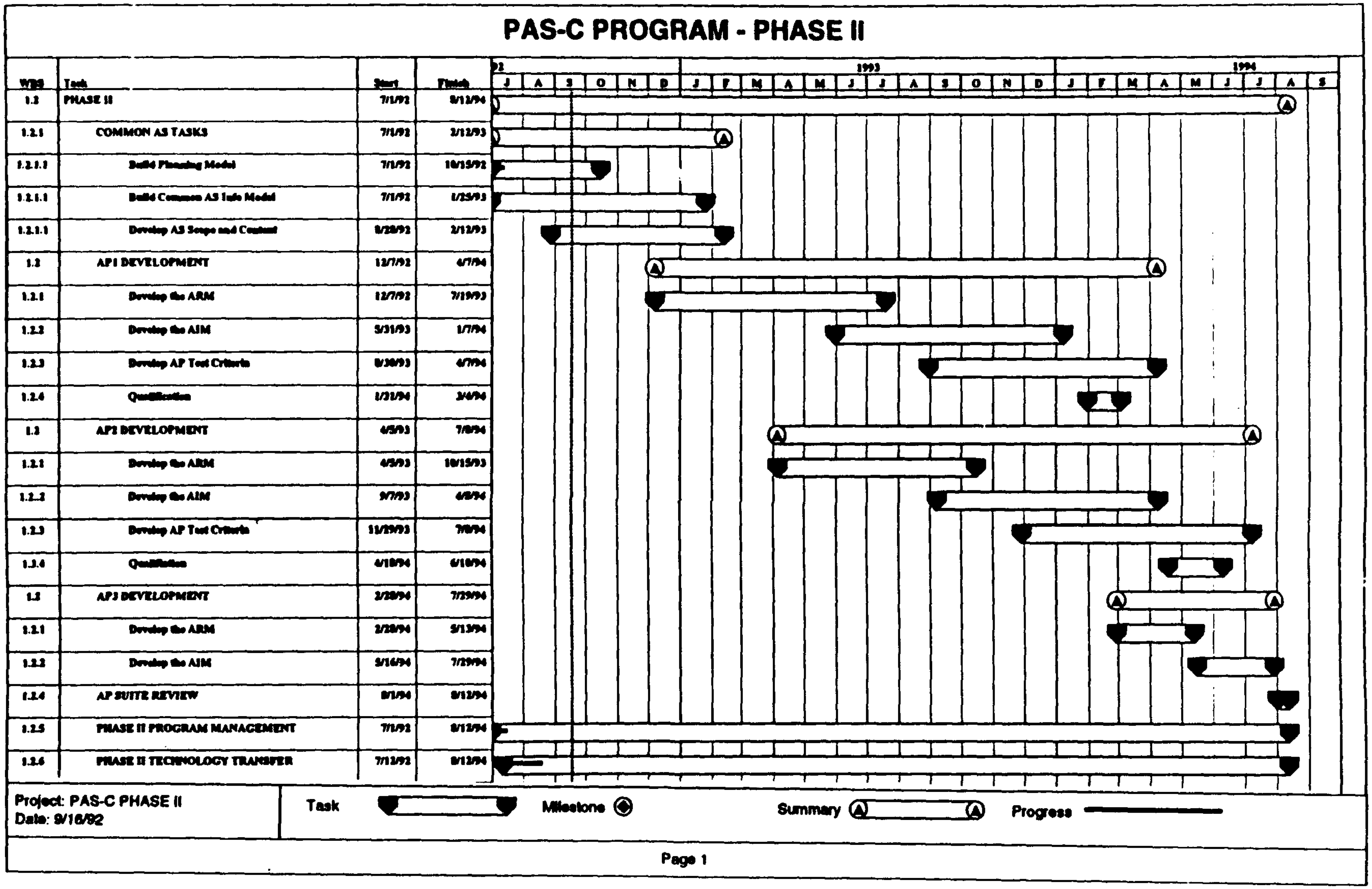

Figure 12 - PAS-C Program Phase II Tasks

2.6 Demonstration Plan

A demonstration plan was created which will validate that all three AP's will perform their designed function. The APs will be demonstrated for the three parts previously selected plus one part furnished by the Air Force. In addition, the demonstration will show that the three AP's are compatible with each other and are an integrated suite of Application Protocols. The APs will demonstrate this functionality across usage scenarios which encompass prime to subcontractor, teaming partner to teaming partner, and prime to Air Force interface. These interfaces will be two way where appropriate and will demonstrate compatibility across the heterogeneous environments which exist within and between the PAS-C team companies.

A significant goal is to identity and spur development of systems and capabilities which can be utilized in the industry. The demonstration will present opportunities where vendor products could be utilized to aid the functions within the scope of this composite application protocol suite. Vendor products which are available to the program at the time of the demonstration will be included in the demonstration and their commercial availability highlighted. The final demonstrated capability will be dependent upon the availability of products which support PDES/STEP database capabilities as well as composite part design, analysis, and manufacturing.

This demonstration will represent a tradeoff of meeting program goals within project schedule and labor constraints. One goal will be validation of the AP as completely as possible. Another will be the involvement of vendors such that commercial products will emerge. The demonstration will also show the capabilities of a PDES/STEP database system in supporting multiple applications simulating real world usage.

The demonstration will involve the five functions of:

- generate demonstration databases,
- perform design tasks,
- perform analysis activities,
- perform manufacturing activities, and
- create support information.

These are shown in Figure 13. When available, existing application programs will be used to perform each of the functions. If applications do not exist, alternate methods, such as database utilities, will be used to accomplish the required information input, output, and query tasks. Throughout this scenario it is assumed that the PDES/STEP format could be either a Level 1 physical file or a Level 3 database. The final decision on which implementation level to use will be primarily dictated by the available resources and tools at the time the demonstration is put together in Phase III.

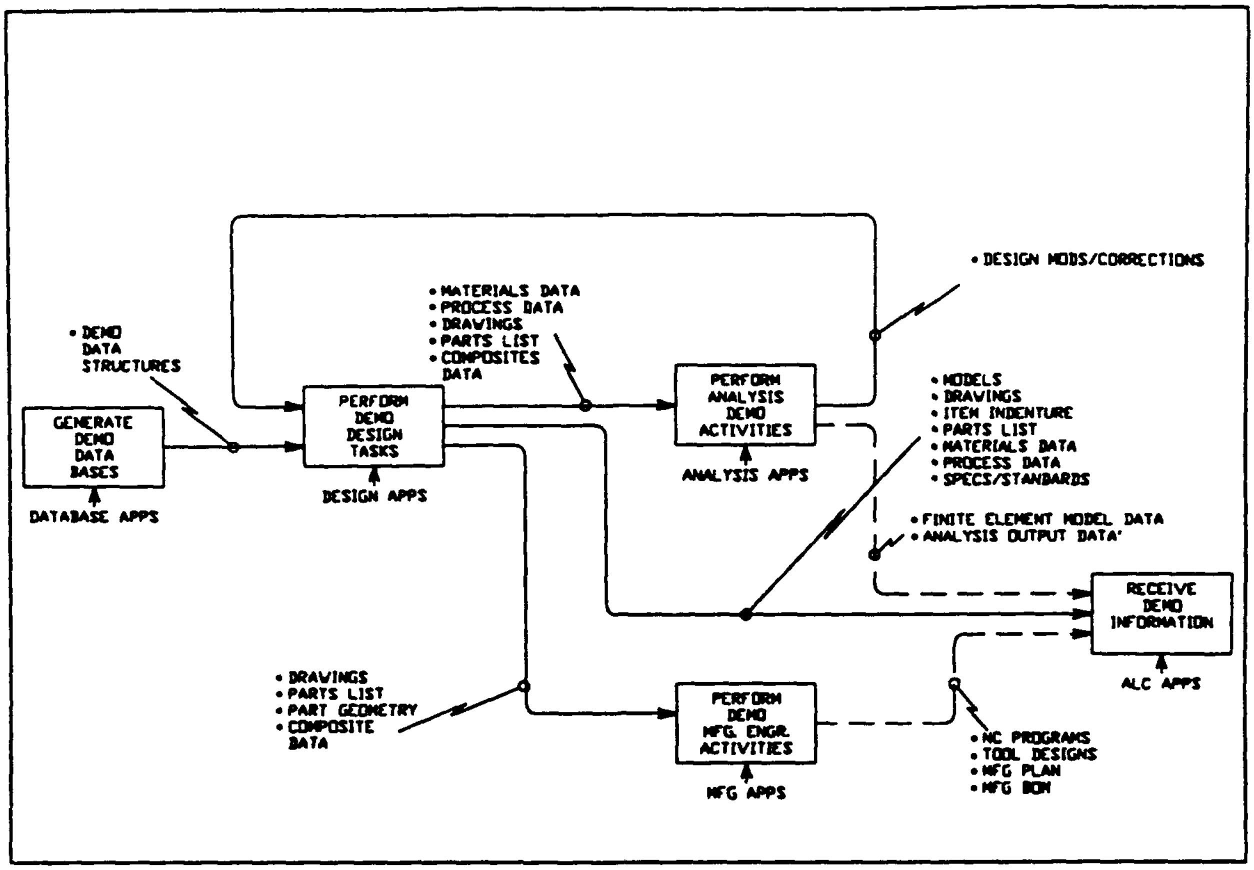

Figure 13 - Demonstration Scenario

The demonstration will use the latest state-of-the-art applications available from the PAS-C team companies or furnished by the vendors for the demonstration. Technical areas of importance are:

- Database capabilities such as Object-Oriented, relational, or hierarchical,
- EXPRESS compilation and database generation and control,
- Standardized interfaces such as STEP Data Access Interface (SDAI), and
- Data dictionary tied to standard query capability.

Each of these technology areas is expected to have major new capabilities available in the time frame of the demonstration. Therefore a final architecture will be selected during Phase III of the PAS-C Program.

The establishment of a Vendor Implementation Group (VIG) is one of the key ingredients in accomplishing industry acceptance of these standard data exchanges (i.e., APs). The PAS-C team will continue to meet with software and hardware vendors individually and collectively in order to keep them abreast of PAS-C's efforts and needs, plus solicit guidance, review and support in achieving demonstration/implementation goals.

An in-depth look at the demonstration scenario and other topics discussed in this section can be found in section 4 of reference [9]. Also included in section 4 of reference [9] is an initial set of implementation issues and a preliminary schedule for the development and execution of the demonstration.

2.7 Technology Transfer

Technology Transfer is an important aspect of the PAS-C Program. Any time a technology is being standardized, like the exchange of composite part information, technology has to be transferred so that a consensus can be obtained. Therefore the PAS-C team has been actively involved in a multitude of technology transfer endeavors. Many of these technology transfer endeavors are embedded within required program tasks. The PDES State-of-the-Art Assessment task is a good example. The PAS-C team not only gave the developers of each STEP Part valuable feedback, but the results were also used as a reference manual for individuals who were trying to get up to speed on PDES/STEP. Another visible technology transfer is the impact the PAS-C development methodology and structure had on the concepts used in the National Institute of Standards and Technology's NIST document *Issues and Recommendations for a STEP Application Protocol Framework* [10]. PAS-C's development schedule and labor hour estimates are being used to help formulate an ISO standard AP development templet so that other AP projects can gain from PAS-C's experience. Other projects that PAS-C has influenced indirectly have been PDES Inc. and the Air Force ManTech PAP-E program. They both have used a Framework/Building-Block style to aid in presenting overall scope of their respective suite of Application Protocols. A result of technology transfer at the international level led to obtaining an ISO STEP Part number for the Design to Analysis Application Protocol. Its official number is AP 209.

On the composite part information side, terminology was obtained from the ASTM organization and the ISO technical committee on Plastics' sub-group, Composite and Reinforcements (ISO TC61/SG13). This terminology was used to insure no conflicting terminology was created.

Technology transfer with the F-22 Program Airframe Integrated Product Team (IPT) has been initiated with the sharing of information exchange requirements. This sharing will continue as F-22 Digital Product Definition Data (DPD) requirements are firmed up. Initial talks with the Air Force ManTech programs Advanced Tooling Manufacture for Composite Structures (ATMCS) and Manufacture of Thermoplastic Composite Preferred Spares (MATCOPS) led to identifying potential synergistic opportunities. Due to the immaturity of the programs at the time of the initial talks, it was agreed to revisit them early in 1993 when each program had additional information to share.

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3 CONCLUSIONS

The past year has been a very productive one. All the tasks were accomplished on schedule and within budget. Two charts from the *PAS-C Program Funds and Man-Hour Expenditure Report* [11] "Phase I Funds Expended" and "Phase I Percent Work Completed" give an overall profile of the expenditures. Phase II, Application Protocol Development, start-up was delayed because of a funding shortage. Because of this funding delay the schedule was adjusted approximately six weeks. The schedule in Figure 12 reflects this adjustment. At the time of this report the program is funded sufficiently to meet scheduled milestones through December 1992.

The PAS-C team has had useful feedback from its Industry Review Board (IRB), made up of industry leaders in composites and information systems technologies. The names and companies of the IRB members are located in Appendix A. The feedback came in the form of keeping the PAS-C team focused on communicating up-front implementation issues and keeping the scope of the Application Protocols well defined so that they are doable. The results of the two IRB meetings can be found in their respective meeting minutes, reference [12] and [13].

The accomplishments of the last year have established a solid foundation to build upon. The PAS-C team will continue to refine the scopes of the three Application Protocols and build a common information model for the suite that will insure/enhance the integration and usability of the APs. The team will also persist to obtain industry buy-in by continuing expert interviews and review sessions. The PAS-C team is pursuing software and hardware vendor support for which the team is refining implementation scenarios and identifying potential marketing opportunities for vendors.

The PAS-C team has made significant accomplishments during the last twelve months, and looks forward to being very successful in the years to come.

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REFERENCES

1. PAS-C Program Project Planning Chart, CDRL A003.

2. Functional Needs Report for the PAS-C Program, Document No. PASC002.01.00, 30 September, 1991.

3. PAS-C Sample Part Set, Document No. PASC003.01.00, 30 September,1991.

4. Functional Needs IDEF0 Activity and Information Models for the PAS-C Program, Document No. PASC006.01.00, 9 January 1992.

5. PDES State-of-the-Art Assessment for the PAS-C Program, Document No. PASC005.01.00, 23 December, 1992.

6. Scoping and Benefits Criteria (Volume I - Executive Summary and Overview) for the PAS-C Program, Document No. PASC007.01.00, 14 May, 1992

7. Scoping and Benefits Criteria (Volume II) for the PAS-C Program, Document No. PASC008.01.00, 14 May, 1992.

8. Program Master Plan for the PAS-C Program, Document No. PMG001.01.00, 30 August, 1991.

9. Development and Demonstration Plan for the PAS-C Program, Document No. PASC010.01.00, 28 May 1992.

10. Issues and Recommendations for a STEP Application Protocol Framework, NISTIR 4755, 17 January 1992.

11. PAS-C Program Funds and Man-Hour Expenditure Report, CDRL A0004.

12. Minutes for the 9 January 1992 PAS-C Industry Review Board Meeting, 16 January, 1992 (SCRA).

13. Minutes for the 18 June 1992 PAS-C Industry Review Board Meeting, 25 June 1992 (SCRA).

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APPENDICES

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APPENDIX A - Industry Review Board

IRB Members/Titles	Company
Julies Olser, Manager, Subsystems Technology F22	Lockheed
Bill Conroy, Chairman IGES/PDES Organization	NIST
Jeane Ford, Program Manager, PDES National Testbed	NIST
Irvin Poston, Manager, Composites, Advanced Engineering Staff	General Motors
Alan Hiken, Manager, Advanced Composite Process	Northrop Aircraft Division
Mike McGrath, Executive Director for Manufacturing	DARPA/SSTO
Lorna Estep, Director - Joint Center for FCIM	DOD Joint Center for FCIM
Dennis K. Rogosch, Deputy Program Manager for PDES National Initiative	Wright Patterson AFB
Bill Henghold, President	HMR Associates
Leiv Blad, President	Composites Automation Consortium, Inc.
John Barnes, PAS-C Program Manager	Wright Patterson AFB

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APPENDIX B - PAS-C Related Documents

Program Master Plan for the PAS-C Program, Document No. PMG001.01.00, 30 August, 1991

Functional Needs Report for the PAS-C Program, Document No. PASC002.01.00, 30 September, 1991

PAS-C Sample Part Set, Document No. PASC003.01.00, 30 September, 1991

1991 Annual Report for the PAS-C Program, Document No. PASC004.01.00, 30 September, 1991

PDES State-of-the-Art (SOTA) Assessment for the PAS-C Program, Document No. PASC005.01.00, 23 December, 1991

Functional Needs IDEF0 Activity and Information Models for the PAS-C Program, Document No. PASC006.01.00, 9 January, 1992

Scoping and Benefits Criteria (Volume I - Executive Summary and Overview) for the PAS-C Program, Document No. PASC007.01.00, 14 May, 1992

Scoping and Benefits Criteria (Volume II) for the PAS-C Program, Document No. PASC008.01.00, 14 May, 1992

Functional Needs/State-of-the-Art Comparison for the PAS-C Program, Document No. PASC009.01.00, 28 May, 1992

Development and Demonstration Plan for the PAS-C Program, Document No. PASC010.01.00, 28 May, 1992

1992 Annual Report for the PAS-C Program, Document No. PASC004.02.00, 30 September, 1992